Attachment 4

Comments on the passage models with respect to the DRAFT Weight of Evidence Report dated 3 July 1998 and implications for extra mortality hypotheses.

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The Weight of Evidence Report provides a fairly complete analysis of the weight of evidence about underlying hypotheses on which the models were structured, and on model outputs and how they relate to hypothesized effects on stock performance. The report carefully notes that the analyses conducted to date have not year considered all of the alternative hypotheses, such as increased releases of hatchery fish, that were recently submitted to PATH. Thus, it is not surprising that three statements in the report identify that the modeling efforts and hypotheses examined, to date, may not adequately represent what factors presently control mortality in the stocks.

> A summary of the first section occurs on lines 28-31, page 58. AIn this context, spawning abundances projected by both aggregate hypotheses appear to be either unreasonably optimistic in their assumptions given the present condition of this particular stock, or both of them are *excluding some source of mortality that has been operating in recent years* (emphasis added).@

> A summary of the second section occurs on lines 4-5, page 96. AIn conclusion, both extra mortality hypotheses *generate unrealistically high escapement* (emphasis added) under the A1 ›current operations= scenario, ...@

> Finally, a third statement further hints at the likely cause of the unrealistic results (lines 36-38, page 86): "[Management implications] are not discussed [in the proposed multi-factor hypothesis], but clearly, if extra mortality is distributed among five different factors, changes in any one factor (such as the hydrosystem) will have less benefit."

The apparently over-optimistic outputs from the prospective models may relate to incorrect assumptions (or model functions) about present mortalities related to the hydropower system or to exclusion from the models of the conditions that presently exert the largest impact on mortality of the stocks.

We address these two possibilities as follows:

I. Incorrect assumptions (or model functions) about present mortalities related to the hydropower system:

Hydropower system survival for juvenile fish is related to the direct passage survival of non-transported fish that pass through the hydropower system (and in the case of the hydropower system hypothesis, extra mortality that is directly proportional to their inriver mortality) and through the D-value applied to fish collected and transported. Estimates of direct passage survival are based on the fundamental tenet that the juvenile passage models adequately estimate the survival of juvenile fish in the hydropower system (non-transported or bypassed fish). The CRiSP and FLUSH models both provide survival estimates of migrant juvenile fish in the hydropower system that match quite favorably with past observed reach survival estimates (Figure 4-3 in DRAFT Weight of Evidence Report.) Nonetheless, in predicting the future, the relative Abest@ estimates of prospective survival through the hydropower system are somewhat higher in CRiSP than in FLUSH (Figure 3-12 in DRAFT Weight of Evidence Report.)

It is not a surprise that the models quite closely predicted the observed survival estimates from the past, after all, it was with these data that the models were calibrated. However, not all available PIT-tag data were used to calibrate the models. We used observed PIT-tag data from 1989 to 1992 and from 1997 and 1998 to evaluate the predictions made by the passage models. Because these data were not used in calibration, they have value to check the validity of the method of projection. We provide the following analyses to show how well the model predictions fit these PIT-tag data, also indicate how lack of fit with the data might bias projections.

1989-1992 PIT-tag data; CRiSP, FLUSH, and observed data

PIT-tag data exist from the years 1989 through 1992, but previously no survival estimates were made for this period because it was not possible to separately estimate survival and detection probabilities in those years. Nonetheless, these data are useful to investigate the degree to which passage model predictions (we obtained model outputs from CRiSP and FLUSH modelers for those years) agree with the proportions of fish detected at each dam. We also assessed some of the values PATH has assumed for FGE.

We looked at data from PIT-tagged yearling chinook salmon released from the Snake River Trap each year from 1989 through 1992. Data were downloaded from PTAGIS and processed using the program "CaptHist," developed by the Columbia Basin Research group at the University of Washington. We used all yearling chinook salmon, including those with "rearing types" hatchery, wild, and unknown. PTAGIS data disagreed slightly with those summarized in Buettner and Brimmer (1996)[1], but general patterns in numbers tagged and detected were the same.

PIT-tagged yearling chinook salmon were released from the Snake River Trap well into the summer in some years. To restrict our analyses to fish that migrated in the spring, we used only fish released before 22 May. This is an arbitrary cutoff (though suggested by the data) but results were changed very little if other cutoff dates were used.

Relatively low Snake River flows occurred from 1989 through 1992 (Figure 1). The mean daily flow in the Snake River between mid-April and the end of May averaged less than 90 kcfs in all 4 years. Virtually no water was spilled at Snake River dams in any of the years. Between 1,200 and 6,200 PIT-tagged yearling chinook salmon were released each year (Table 1). The

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[1] Buettner, E. W. and A. F. Brimmer. 1996. Smolt monitoring at the head of Lower Granite Reservoir and Lower Granite Dam. Annual Report to the Bonneville Power Administration, Contract Number DE-BI79-83BP11631. 89 p. (Available from BPA, Public Information Center - CKPS-1, P.O. Box 3621, Portland, OR 97206.)

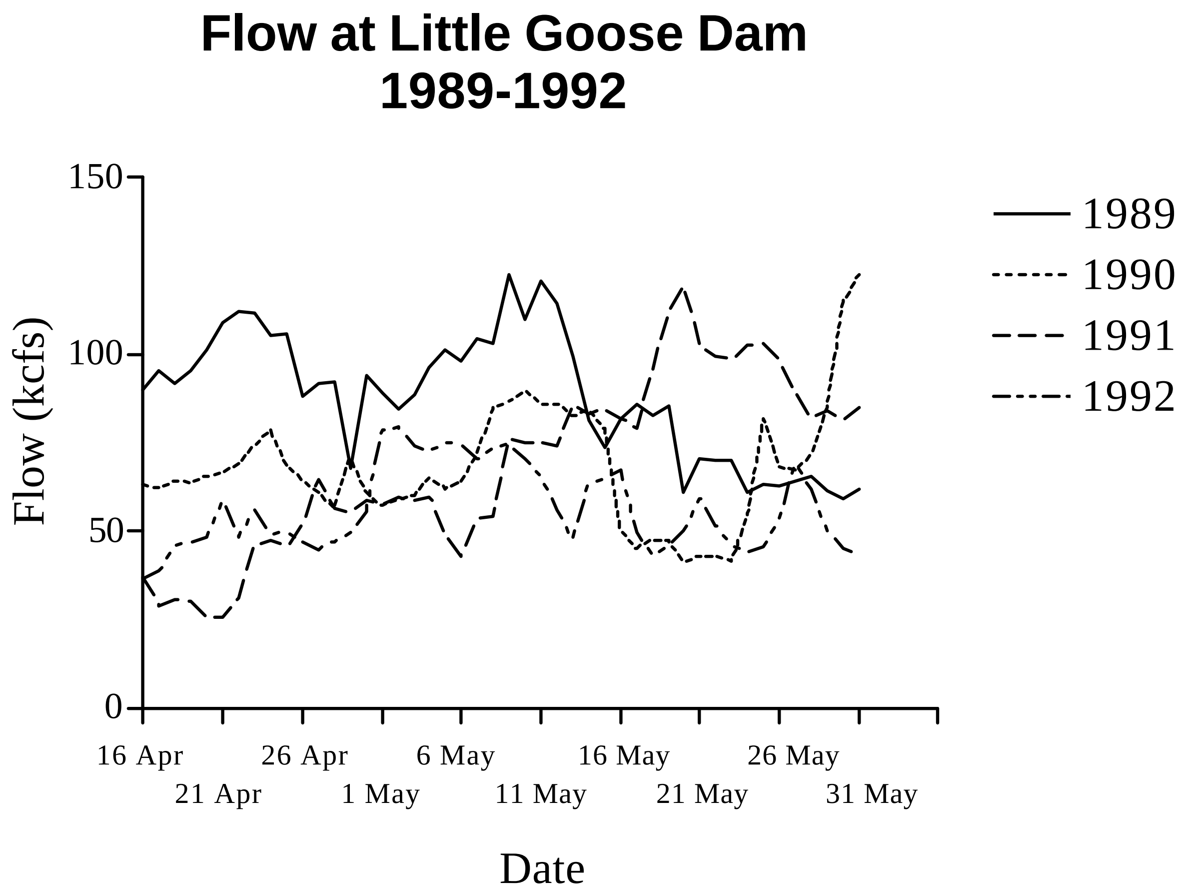
percentage detected at Lower Granite Dam varied little, ranging from 35.6 to 41.4%. The percentage detected at McNary Dam ranged from 6.1 to 10.5% over the 4 years.

Methods

We created a simple spreadsheet model to calculate the expected proportion of yearling chinook salmon detected at McNary dam from yearling chinook salmon released at the Snake River Trap. The spreadsheet was based on the following equation for the proportion:

Table 1. Summary of observed data from PIT-tagged yearling chinook salmon released from Snake River trap 1989-1992.

	Year			
	1989	1990	1991	1992
Release dates	3/24-5/21	4/9-5/13	4/6-5/20	4/7-5/19
Number released	6,163	1,952	3,262	1,195
Number detected at Lower Granite Dam	2,330	793	1,349	426
Percentage detected at Lower Granite Dam	37.8	40.6	41.4	35.6
Number of detected fish returned to river at Lower Granite Dam	110	100	249	0
Number detected at Little Goose Dam	1,070	253	575	194
Number of detected fish returned to river at Little Goose Dam	173	0	0	1
Number detected at McNary Dam	451	174	198	125
Percentage detected at McNary Dam	7.3	8.9	6.1	10.5



Flow at Little Goose Dam
1989-1992
150
100
50
0
Flow (kcfs)
16 Apr
21 Apr
26 Apr
1 May
6 May
11 May
16 May
21 May
26 May
31 May
Date
1989
1990
1991
1992

$$P(McNary) = S_1(1 - P_{T1})S_2(1 - P_{T2})S_3P_3$$

where S_1 = the probability of survival from the trap to Lower Granite Dam,
P_{T1} = the probability of transportation from Lower Granite Dam, given survival to the dam,
S_2 = the probability of survival from Lower Granite Dam to Little Goose Dam,
P_{T2} = the probability of transportation from Little Goose Dam, given survival to the dam,
S_3 = the probability of survival from Little Goose Dam to McNary Dam, and
P_3 = the probability of detection at McNary Dam, given survival to the dam.

We assumed that the transportation probabilities were equal to the FGE values assumed by PATH at the dams, because there was no spill and almost all detected fish were transported (Table 1). The FGE values used for PATH modeling are 35% at Lower Granite Dam in 1989 and 1990, and 46% in 1991 and 1992; 58% at Little Goose Dam all years; and 56% at McNary Dam all years. We used two alternative sources to inform our choices for survival estimates in our spreadsheet model:

1) Snake River survival estimates made by NMFS in the 1970s (data from Sims and Ossiander 1981[2]).

We used a per-project survival probability calculated from the following equation derived

$$S = 13.05 flow^{0.376}$$

from the Sims and Ossiander points:
where flow is expressed in kcfs and survival in percentage. For flow values each year, we used the following "flow-exposure indices" based on passage distributions at Little Goose Dam: 97.8, 63.6, 84.6, 69.1 kcfs for 1989, 1990, 1991, and 1992 respectively.

2) Snake River survival estimates based on NMFS survival studies with PIT-tags in 1994 and 1995 (data from Smith et al. 1998[3]).

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[2]Sims, C. W., and F. J. Ossiander. 1981. Migrations of juvenile chinook salmon and steelhead trout in the Snake River from 1973 to 1979, a research summary. Final Report to U.S. Army Corps of Engineers, Portland, OR. 31 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

[3]Smith, S. G., W. D. Muir, E. E. Hockersmith, S. Achord, M. B. Eppard, T. E. Ruehle, J. G. Williams, and J. R. Skalski. 1998. Survival estimates for passage of juvenile chinook salmon through Snake River dams and reservoirs, 1996. Annual report to Bonneville Power Administration,Portland, OR, Contract DE-AI79-93BP10891, Project 93-29, 197 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

In 1994 and 1995, we estimated survival for a number of release groups from the tailrace of Lower Granite Dam to the tailrace of either Lower Monumental or McNary Dam. We adjusted derived per-project survival estimates from release groups that migrated with median flows of 75kcfs (range 51 to 90 kcfs in 1994 and 62 to 88 kcfs in 1995).

We also looked at travel times under the seasonal flows identified above for the fish in 1989 to 1992 and compared them with travel times of fish observed in 1994 and 1995 that migrated in flows less than 90 kcfs.

Results

The median travel times ranged from 19.9 to 23.8 days for fish that migrated in 1989 to 1992 and in 1994 and 1995 ranged from 16.8 days (wild) to 20.8 days (hatchery) for fish that migrated under flows less than 90 kcfs (Table 2).

Our spreadsheet model that used 1995 survival estimates provided predictions of the number of fish that arrived at McNary Dam that were closest to the actual observed numbers (Table 3). The predictions of the number of detected fish at McNary Dam from our spreadsheet model that used the Sims-Ossiander data and those provided from the CRiSP and FLUSH models were similar to the actual observations in 1989, but much lower than the actual number of fish detected from 1990 to 1992.

When we used the PATH FGE values and the Sims-Ossiander derived survival estimates, our spreadsheet model provided per-project survival estimates from the Snake River trap to McNary Dam of 0.731, 0.629, 0.703, and 0.638, for the years 1989 through 1992, respectively (Table 4); whereas, estimated per-project survivals based on recent PIT-tag studies for fish that migrated through the Snake River under flows less than 90 kcfs were 0.892 (derived from survival estimates from the tailrace of Lower Granite Dam to the tailrace of McNary in 1995). (The per-project survival estimate derived from survival estimates from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam in 1994 and 1995 was 0.859.) The outputs from CRiSP and FLUSH are also included in Table 4 and displayed in Figure 2.

Discussion

The predicted number of Snake River fish detected at McNary Dam from 1989 through 1992 based on our spreadsheet model that used NMFS survival data (Sims and Ossiander) from the 1970s was poor (Table 3). Three factors could have contributed to these poor results: (1) the assumed FGE at McNary Dam was too low; (2) the assumed FGE at Lower Granite and Little Goose Dams were too high; thus, too many fish were assumed removed from the population for transportation which left fewer to arrive at McNary Dam; and/or (3) assumed survival probabilities in our spreadsheet model were too low; thus, fewer fish were predicted to arrive at McNary Dam. We address these issues as follows:

Factor 1 - potentially erroneous FGE at McNary Dam does not appear to explain the difference between model and observed data. The assumed FGE estimate for McNary Dam is

Table 2. Yearling chinook salmon median travel time (days) from the Snake River Trap to McNary Dam, 1989-1996:

	Fish classification			
Year	Hatchery	Wild	Unknown*	Median flows (kcfs)
1996	19.3	17.0		
1995	19.6	16.8		<75
1994	20.8	20.1		<75
1993	15.0	17.6		
1992			23.8	69
1991			21.7	85
1990			19.9	64
1989			23.0	98

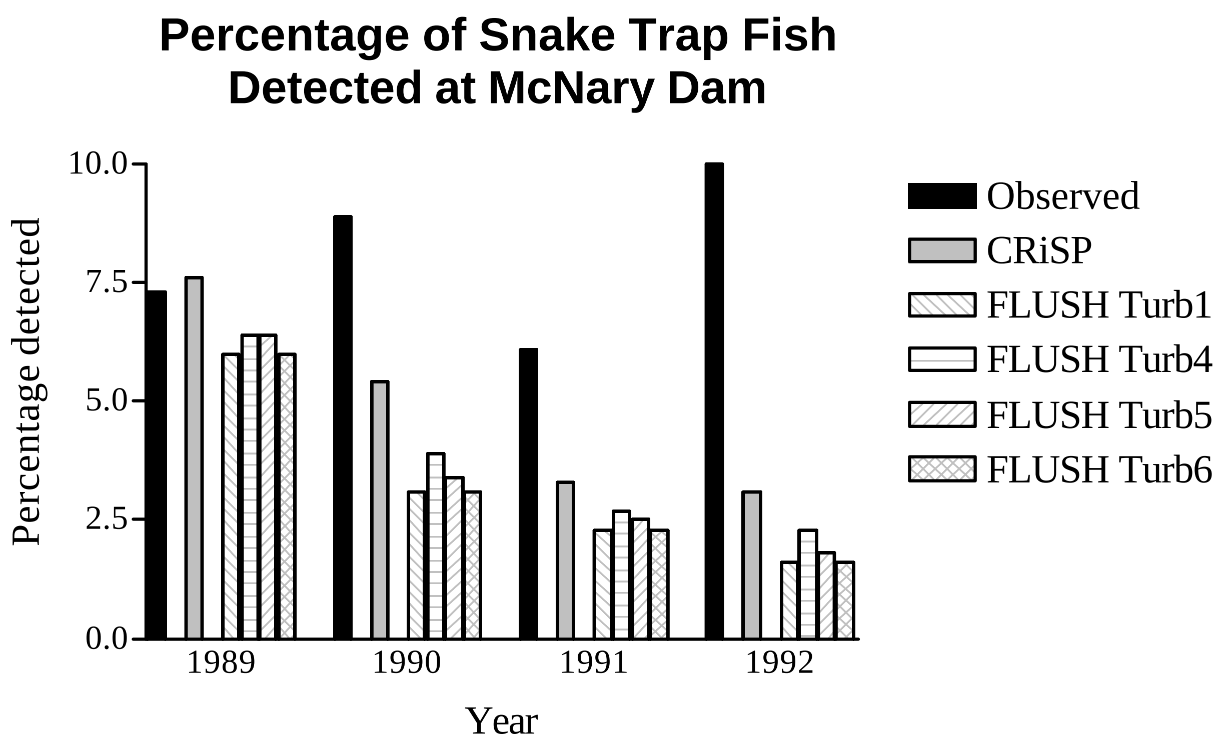
*Based on size distribution of tagged fish, most were likely hatchery origin

Table 3. The observed percentage of PIT-tagged yearling chinook salmon released from Snake River trap detected at McNary Dam by year and predictions for each year based on various models.

	1989	1990	1991	1992
Observed	7.3	8.9	6.1	10.5
"Sims & Ossiander"	3.2	1.5	2.2	1.3
1995 low-flow	8.6	8.6	7.2	7.2
CRiSP	7.9	5.8	3.6	3.6
FLUSH Turb1	6.0	3.1	2.3	1.6
FLUSH Turb4	6.4	3.9	2.7	2.3
FLUSH Turb5	6.4	3.4	2.5	1.8
FLUSH Turb6	6.0	3.1	2.3	1.6

Table 4. Per-project survival probabilities implied by observed detection percentages at McNary Dam and by CRiSP and FLUSH model results. The observed values are based on assumed FGE estimates used by PATH.

	1989	1990	1991	1992
Observed	.862	.883	.845	.959
CRiSP	.876	.823	.776	.776
FLUSH (mean)	.835	.740	.725	.680
Mean estimated under low flows 1995	.892	.892	.892	.892



lower than most estimates observed in the field. However, even if FGE at McNary Dam were actually 100% it would not account for the large discrepancy.

Factor 2 - FGE estimates assumed by PATH match the best FGE study estimates observed in the field. However, it appears the FGE value (35%) assumed by PATH for Lower Granite Dam, at least in 1989 and 1990, was too low, as the detection rate at Lower Granite Dam of fish released at the Snake River trap was greater than 35% in all years (Table 1). The observed detection rates are minimal values, as some proportion of fish died before arriving at Lower Granite Dam. PATH has assumed that FGE at Lower Granite Dam was 46% in 1991 and 1992. The 46% FGE assumed for 1991 and 1992 at Lower Granite Dam is slightly higher than observed detection rates, but the actual probability of guidance is higher than the detection rates when survival from the Snake River Trap to Lower Granite Dam is considered (this value is unknown.) If the 46% FGE was correct, then the proportions of fish detected imply that survival from the Snake River Trap to Lower Granite Dam was 90% in 1991 and 77% in 1992. Field estimates of FGE at Little Goose Dam were consistently higher than 58%. The latter value matches a sparse data set on probability of detection at the dam from PIT-tag studies. In any case, it appears that the percentages of fish in each year collected for transportation at both dams was not likely overestimated. Furthermore, even if true FGE were 0% at Lower Granite and Little Goose Dams, the survival probabilities derived from the Sims & Ossiander equation are too low to "deliver" enough fish to McNary Dam to match the observed data.

Factor 3 - It appears that the most likely cause of the differences between our modeled estimates of fish detection at McNary Dam and those observed were our use of survival estimates that were too low. If we assume that the PATH FGE values are correct, then not only does our model provide per-project survival probabilities that are too low, but it implies survival estimates used in the CRiSP and FLUSH models are too low for most of these low-flow years.

Conclusions

In every year, the CRiSP predictions are closer to the observations than those from the and the FLUSH model our spreadsheet model that used survival estimates from the 1970s. Nonetheless, CRiSP predictions are considerably lower than the observed percentages in 3 of 4 years. Predictions closet to observed detections were obtained when we used our spreadsheet model with survival estimates derived from 1990s data.

In 3 out of 4 years, FLUSH predictions are closer to our spreadsheet model based on the Sims and Ossiander survival estimates in the 1970s than they are to the observed data. The exception is 1989, which had the highest flows of the 4 years.

The true survival probability from the Snake River Trap to McNary Dam between 1989 and 1992 was apparently much more similar to that estimated from recent PIT-tag survival studies in the mid-1990s than to those estimated in the 1970's, even with lower average flows than observed in 1994 and 1995. Models used to project passage survival in the future must reflect that relatively high survival is possible (and has occurred) under low flows in the Snake River.

1997-1998 PIT-tag survival estimates; CRiSP and FLUSH estimates

The NMFS began new survival studies in 1993 utilizing PIT tags to mark fish and slide gate technologies at Snake River dams to return detected PIT-tagged fish back to the river. From 1993 to 1996, survival estimates encompassed parts of the Snake River from the reservoir upstream of Lower Granite Dam to either the tailrace of Lower Monumental Dam or McNary Dam. These values were used in model calibration (Figure 4-3 in DRAFT Weight of Evidence Report.) From PIT-tagged fish releases or detections at Lower Granite Dam in 1997 and 1998, we were able to estimate survival from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam. These estimates were not part of calibration efforts and were not provided to modelers. We received estimates from CRiSP for 1997 and 1998 and from FLUSH for 1997. We provide our survival estimates below and compare them to available model outputs.

Methods

For 1998, we estimated the detection probability at Bonneville Dam using the Cormack-Jolly-Seber (CJS) techniques employed in all of our previous survival estimation procedures (e.g., Smith et al. 1998). The release group of wild yearling chinook salmon included all fish tagged and released at Lower Granite Dam in 1998. Detection probability at Bonneville Dam was estimated using detections by the PIT-tag trawl sampling below Bonneville Dam.

For 1997, the CJS was not useable to estimate the Bonneville Dam detection probability, as sampling below the dam was inadequate. Instead, we used data on coho salmon released at The Dalles Dam in 1997 (approximately 45,000 tagged fish) and 1998 (approximately 66,000) as part of a study to estimate survival of fish that passed through the spillway at the dam. We calculated the ratio between 1997 and 1998 detection proportions for coho salmon, then multiplied the ratio by the 1998 Bonneville Dam detection probability for chinook salmon to obtain a detection probability estimate for 1997.

We calculated the proportion of fish in each of three release groups of wild yearling chinook salmon (detected and bypassed at Lower Granite Dam in 1997, detected and bypassed at Lower Granite Dam in 1998, and released at Lower Granite Dam in 1998) that were detected at Bonneville Dam. Finally, we estimated the survival probability from Lower Granite Dam tailrace to Bonneville Dam tailrace for each of the three release groups. For 1998 we used two techniques for survival estimation. The first was the standard CJS method. The second estimate was derived by dividing the proportion of fish detected at Bonneville Dam by the estimated probability of detection at the dam. The CJS method results in survival estimates that are adjusted for fish removed for transportation from Little Goose and Lower Monumental Dams, while the adjusted-proportion method does not and consequently provides a lower survival estimate. The ratio between the CJS estimate and the adjusted-proportion method is an estimate of the bias in the adjusted-proportion method. For 1997, the CJS method was not possible, so we applied the adjusted-proportion method and adjusted for bias by applying the ratio of the two estimates for 1998.

Results

The CJS estimate of detection probability for wild chinook salmon at Bonneville Dam in 1998 was 14.4% (s.e. 3.2%), based on 118 fish detected below the dam, of which 17 were also detected at the dam. The proportions of coho salmon detected at Bonneville Dam from releases made at The Dalles Dam were 0.120 and 0.123 in 1997 and 1998, respectively. We applied the ratio of the two (0.120/0.123 = 0.976) to the detection probability for Snake River yearling chinook salmon in 1998 to derive an estimated detection probability for wild chinook salmon in 1997 of 14.0% (s.e. 3.2%).

The proportion of fish detected at Bonneville Dam from wild yearling chinook salmon released or detected/bypassed at Lower Granite Dam ranged from 5.9% in 1997 to 7.8% in 1998 (Table 5). The CJS estimate for Lower Granite Dam to Bonneville Dam survival of fish tagged and released at Lower Granite Dam in 1998 was 58.3% (s.e. 12.9%), and the survival probability estimate from the adjusted-proportion method (not accounting for removals for transportation) was 53.8% (s.e. 12.1%). The ratio of the two estimates was 1.083 (58.3/53.8). This ratio was applied to survival estimates from the adjusted-proportion method for fish released above Lower Granite Dam and detected and bypassed at the dam, resulting in survival estimates from Lower Granite Dam tailrace to Bonneville Dam tailrace of 45.5% and 57.3% in 1997 and 1998, respectively.

Our estimate of 45.5% in 1997 compared to a CRiSP estimate of 46.4%. FLUSH provided estimates of survival from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam under four different TURB assumptions. The estimates ranged from 40.1% to 42.6%, with an average of 41%. Applying a survival rate of 94% for the Lower Granite project to the average gives a tailrace-to-tailrace estimate of 43.6%.

The average of our two estimates for 1998 was 57.8%, compared to the prediction of 52.3% from the CRiSP model. FLUSH output was not available for 1998.

Discussion

The CRiSP model prediction for was slightly higher than our estimate in 1997 and slightly lower in 1998. The FLUSH prediction in 1997 was slightly lower. Thus, both models provided survival estimates that much more closely match the estimates we calculated from empirical data under the high flows and spills of 1997 than they did for the lower flow and spill years 1989-1992. The CRiSP prediction for 1998 also matched our estimate more closely. It is unknown if the FLUSH model will provide estimates that agree with empirical data in 1998.

Implications for passage survival based on model outputs and recent data

Model outputs matched empirical reach survival estimates quite closely in periods other than 1989-1992 and 1997 and 1998 (Figure 4-3 in DRAFT Weight of Evidence Report), suggesting that the models will predict future passage surviva reasonably welll. However, the analyses we conducted here suggest that this is not necessarily the case. Both models underestimated survival, sometimes considerably so, under the low flow conditions that existed from 1989 to 1992. Two of three available model predictions under high flow conditions were lower than the empirical estimates, though the degree of bias (if any) was much less than for 1989-1992. Our

Table 5. Proportion of fish detected at Bonneville Dam from wild yearling chinook salmon released or detected and bypassed at Lower Granite Dam, 1997-1998.

Year	Group	Number released	Number detected	Proportion	s.e.

1997	Detected and bypassed at LGR	965	57	5.9%	0.8%
1998	Detected and bypassed at LGR	7,550	575	7.6%	0.3%
1998	Released at LGR	10,023	777	7.8%	0.3%

analyses cover periods with a range of flows that covers all of the historical flow ranges, with the possible exception of extremely low flows in 1977, suggesting that the projections of the life cycle models into the future will incorporate underestimates of the survival of fish that migrate downstream through the hydropower system. We do recognize that our survival estimates in 1997 and 1998 were for PIT-tagged fish that were collected and bypassed at the dams, in addition to PIT-tagged fish that passed through spill or turbines. For these two particular years, our survival estimates were possibly slightly higher than for a population of fish that did not include members bypassed back to the river at Little Goose and Lower Monumental Dams. Nonetheless, our general conclusion is unchanged.

The hydropower system hypothesis assumes that the post-Bonneville Dam extra mortality factor for non-transported smolts is proportional to their inriver mortality. As inriver mortality decreases, so to does the extra mortality. Further, the extra mortality of transported fish is related to the extra mortality of non-transported fish through the D parameter. Thus, prospective estimates of survival are heavily dependent on passage model results. We suggest that survival through the hydropower system is now as high as it was prior to 1969 when Snake River fish had to pass through only four dams (John Day Dam came on line in September 1968 so juveniles in the spring of 1968 did not face turbine passage.)

To indicate how survivals have changed, we have taken the reach survival estimates used in Figure 4-3 (Weight of Evidence Report) and expanded them to estimate the entire hydropower system survival, as follows:

The estimates used in Figure 4-3 from 1964 to 1980 were for reaches composed from the upper dam on the Snake River to Ice Harbor Dam and from Ice Harbor Dam to either John Day Dam or The Dalles Dam (Raymond 1975 or annual unpublished NMFS reports). In all cases, per-project survival from the latter reach were higher than in the Snake River reach. We used the yearly per-project survival estimated in the lower reach as an estimate of per project survival from either The Dalles Dam or John Day Dam to the tailrace of Bonneville Dam. Thus, from The Dalles or John Day Dams, fish passed through an additional 2 or 3 dams (turbines or spill) and 1 or 2 reservoirs, respectively. No estimates of survival were available for the period 1981 to 1992. From 1993 through 1995, we expanded the largest reach over which we had survival estimates (number of dams in parentheses) to estimate survival through the entire hydropower system (8 dams). The 1993 survival estimate was from above Lower Granite Dam to the tailrace of Little Goose Dam (2 dams and reservoirs), in 1994 from above Lower Granite Dam to the tailrace of Lower Monumental Dam (3 dams and reservoirs), and in 1995 from above Lower Granite Dam to the tailrace of McNary Dam (5 dams and reservoirs). From 1996 through 1998, we made no estimates of survival through Lower Granite Reservoir to the tailrace of Lower Granite Dam, so we used a value of 91% (lower end of range of survival estimates from previous years. In 1996, the survival estimate was from the tailrace of tailrace of Lower Granite Dam to the tailrace of McNary Dam (4 dams and reservoirs), and in 1997 and 1998 from the tailrace of Lower Granite Dam to the tailrace Bonneville Dam (7 dams and reservoirs).

Based on our expansion of survival estimates, the estimated survival of fish through the hydropower system from 1964 through 1980 ranged from 2 to 41%, and from 1993 through 1998 ranged from 31 to 53% (Figure 3). Thus, measured survival of fish through the hydropower system decreased considerably with construction of Little Goose Dam in 1970 and fluctuated at comparatively low levels through 1980. However, survival through the presently configured hydropower system with eight dams and reservoirs has improved considerably over the 1970s and now equals survival in the hydropower system when only four dams and reservoirs existed. This suggests that extra mortality of non-transported fish should equal extra mortality before completion of the hydropower system. Nonetheless, the stocks have not shown a response even with a doubling of non-transported fish survival. Since estimates of SARs in the 1960s through 1970 ranged from 4-7%, and estimates in recent years have remained below 1% (Figure 4-10a Weight of Evidence Report) with equal levels of survival for juvenile smolts through the hydropower system, it indicates that something other than the hydropower system presently has a large effect on the stocks. This matches the conclusion on lines 28-31, page 58. This suggests incorrect assumptions about controlling factors affecting the stocks.

Figure 3. Estimated survival of juvenile yearling chinook salmon from the Snake River through the entire hydropower system based on expansions of measured survival over partial reaches of the hydropower system. In 1964, the hydropower system was composed of Bonneville, The Dalles, McNary, and Ice Harbor Dams. John Day Dam began to produce power in September 1968, Lower Monumental Dam in May 1969, Little Goose Dam in May 1970, and Lower Granite Dam in April 1975.

II. Incorrect assumptions about what conditions presently exert the largest impact on mortality of the stocks.

Hydropower, "BKD", and climate are the three main hypotheses that have received the most attention to date in the PATH process as factors that may have the largest influence on stock performance. However, most of the analyses have used the hypotheses singly to explain observed stock performance during the period of BY 1975 to 1990 . This has simplified the modeling efforts, but may have masked changes in conditions over the larger span from pre-hydropower system completion (prior to 1968 or BY 1966) to the present. It is clear that the construction and operation of dams had a large effect on the downstream migration of Snake River stocks in many of the early years after their construction. However, it seems equally clear that the dams did not have much of an effect on SARs in other years.

There was little to no decrease in SARs (Figure 4-10a Weight of Evidence Report) the first year after John Day Dam and each of the Snake River dams were completed (1968/69 for John Day Dam, 1969 for Lower Monumental Dam, 1970 for Little Goose Dam, and 1975 for Lower Granite Dam). Further, in 1982 SARs rebounded from previous low levels, dropped in 1983 and 1984 and then rose again in 1985 to levels nearly equal to those that occurred when only four dams existed. Thus, between 1968 and 1985 (hydropower system nearly complete, or completely in place) 7 (39%) of the 18 years had SARs that were equal, or nearly equal to historic SARs[4] (analyses of Columbia and Snake River stocks with the Delta model also showed low μ's during these 7 years) (Submission 9 in Appendix).

It appears likely that multiple factors have affected the Snake River stocks between 1964 and present and that single hypotheses (even when used in an aggregate form) do not explain the observed changes in stock performance over time. To adequately address extra mortality that has affected the stocks over the entire period will require consideration of multiple-factor hypotheses such as the one proposed in Submission 11 in the Appendix of the Weight of Evidence Report. In further developing such an analysis, attention should be given to additional factors that may have affected extra mortality in recent years (e.g., increases in populations of marine mammals and shad).

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[4] The 7 years of relatively high SARs all had one thing in common with historic conditions when only 4 dams were in place: little to no debris existed in the forebay of the first dam encountered by migrating juvenile fish. In 1969, 1970, and 1975 debris did not exist because it was the first year that the dams were operated and debris had not yet collected. Similarly, a debris boom was placed in the forebay of Lower Granite Dam in 1982 and debris was removed from the face of the powerhouse. Yet, SARs decreased in 1986 (BY1984) and have remained low since, despite the fact that debris was no longer an issue.